# Mating system

Four major mating systems

1. Monogamy
2. Polygyny
3. Polyandry
4. Polygyandry

1. Monogamy: one male and one female form a mating pair-bond during a given breeding season.

*Some monogamous pair-bonds persist for lifetime…

*Some are sequential monogamy.

*Most species are socially monogamous (not genetically).

2. Polygyny: A male fertilizes the eggs of several females during a given breeding season.

3. Polyandry: a female mates with more than one male during a given breeding season.

Wattled Jacana

Females are larger; defend territories

Males take care of young

4. Promiscuous: both males and females mate with many partners.

Barbary macaque

Birds: more than 90% bird species are socially monogamous.

Mammals: more than 90% mammalian species are polygynous.

Why and how different mating systems evolve?

1. Ultimate causes
   - resource distribution, sex ratio….

1. Proximate causes
   - genes, hormones, neural systems…

Why evolve monogamy ?

How can it possibly be advantageous for a male to inseminate only one female per breeding season?

According to sexual selection theory, a male's reproductive success is related to the number of females he inseminate.

The benefit of evolving monogamy in male must be greater than the benefit of polygamy.

Why evolve monogamy ?

How can it possibly be advantageous for a male to inseminate only one female per breeding season?

1. Mate assistance:

   Males remain with a single female to help rear their mutual offspring, otherwise the offspring might not be able to survive.

2. Mate guarding:

   If a female left by one male would probably acquire another mate, whose sperm would then fertilize her eggs.

Why monogamy is exceptionally rare in mammals?

-- the nature of mammalian pregnancy and milk production in females.

-- males can look for other females and increase their reproductive success.



5~10% of mammals are monogamous

And the males tend to be good father!

--Several species of hamsters

--California mouse

Females have to search for food for the babies (food resource is limited)
→ demand bi-parental care.

Why most birds are monogamous?

-- the young of most birds require tremendous amount of parental care

-- male birds can increase their reproductive success by helping incubating eggs and feeding nestlings.




Although most birds are monogamous..

-- fewer species are faithful to their partners

Common Loons: 100% paternity to their social mate

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Walter H. Piper · David C. Evers · Michael W. Meyer
Keren B. Tischler · Joseph D. Kaplan · Robert C. Fleischer

# Genetic monogamy in the common loon (*Gavia immer*)

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**Abstract** We conducted behavioral observations and genetic analysis on breeding pairs of common loons in the upper Great Lakes region from 1993 through 1995 to look for behavioral evidence of extrapair copulations (EPCs) and to determine parentage of young. Pairs remained close to each other (usually within 20 m) during the pre-laying period, leaving little opportunity for EPCs to occur. Males and females both maintained physical proximity by approaching each other when they became separated. Copulations were obvious but infrequent, occurring about once every other day during the pre-laying period. Multilocus DNA fingerprinting was consistent with behavioral findings: 58 young from 47 different families were all genetic offspring of parents that raised them. Perfect genetic monogamy (genetic parentage of young by parents that rear them) in loons might arise as a consequence of the need for vigorous territorial defense to prevent territorial takeover.

**Key words** Loon · Parentage · DNA fingerprinting monogamy

## Introduction

The recent burst of molecular analysis of parentage has revealed that many socially monogamous animals, especially perching birds (Order: Passeriformes), engage in extrapair copulations (EPCs) with other, often neighboring, individuals (Westneat 1990; Gibbs et al. 1990; Stutchbury et al. 1994; Dixon et al. 1994). A number of hypotheses have been offered to explain EPCs. Females might benefit from EPCs by mating with males that are superior to their social mates in terms of genetic quality, thus acquiring superior genes for their offspring (Smith 1988; Møller 1991). Females might seek or accept EPCs as insurance against the possibility of their mate's infertility (Wetton and Parkin 1991; Wagner 1992). Finally,

Although most birds are monogamous..

-- most species regularly copulate outside the pair bond: extra-pair copulation

-- identified by extra-pair paternity using DNA microsatellite analysis

-- Why do females have extra-pair copulation, when they have a partner to help parental care and/or defending resources ?

Although most birds are monogamous..

-- why many females have extra-pair copulation?

1. Good gene hypothesis:

   her social mate might not have the best gene.

2. Fertility insurance :

   reduce the risk of having an infertile male partner.

3. Genetic compatibility hypothesis:

   increase genetic variety of the sperms

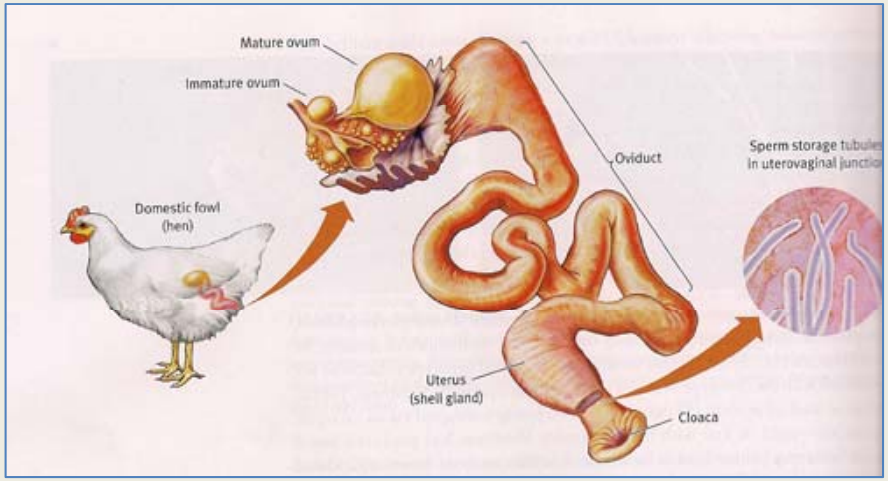
4. Material benefit:

   better protection, access to resources

# Sperm competition

Direct competition between the sperm of different males to fertilize a female's eggs –or mating success.

In many species, females mate with many males, store sperms from numerous matings, sperms from different males may compete with one another over access to fertilizable eggs.

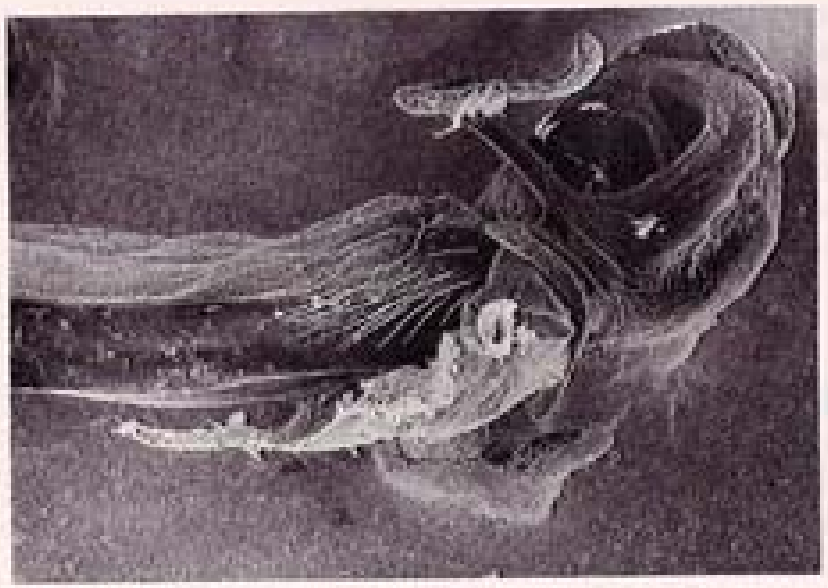


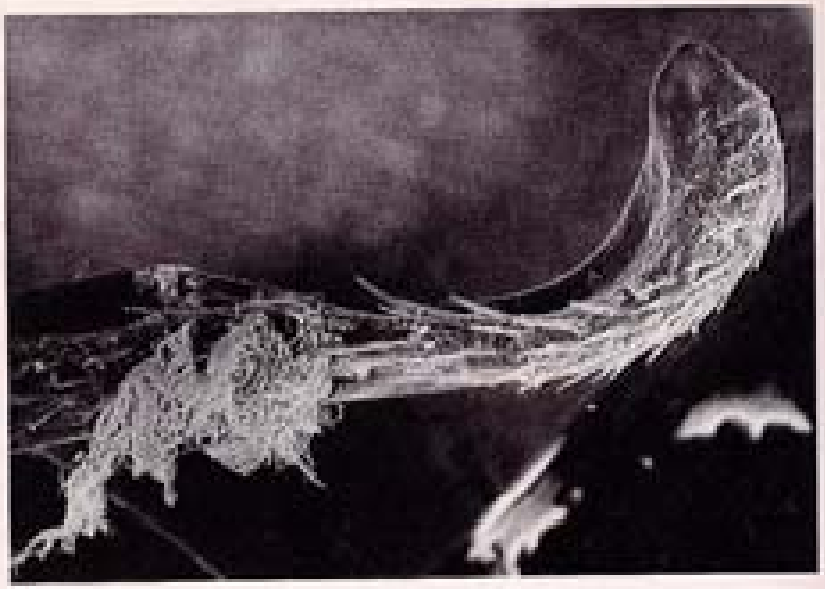
# Sperm competition

Black-winged damselfly

# Sperm competition

## Black-winged damselfly





**23 Sperm competition in the black-winged damselfly.** (Left) The male's penis has lateral horns and spines that enable him to scrub out a female's sperm storage organ before passing his own sperm to her. (Right) A close-up of a lateral horn reveals rival sperm caught in its spiny hairs. Photomicrographs by Jon Waage, from Waage (1177).

2. Polygyny: A male mates with several females during a given breeding season.

- Female defense polygyny
- Resource defense polygyny
- Lek polygyny

Lek polygyny:

Lek: males set up and defend small arenas

--only for mating;

--no apparent food resource.

# Lek polygyny

Sharp-tailed Grouse

# Resource-defense polygyny

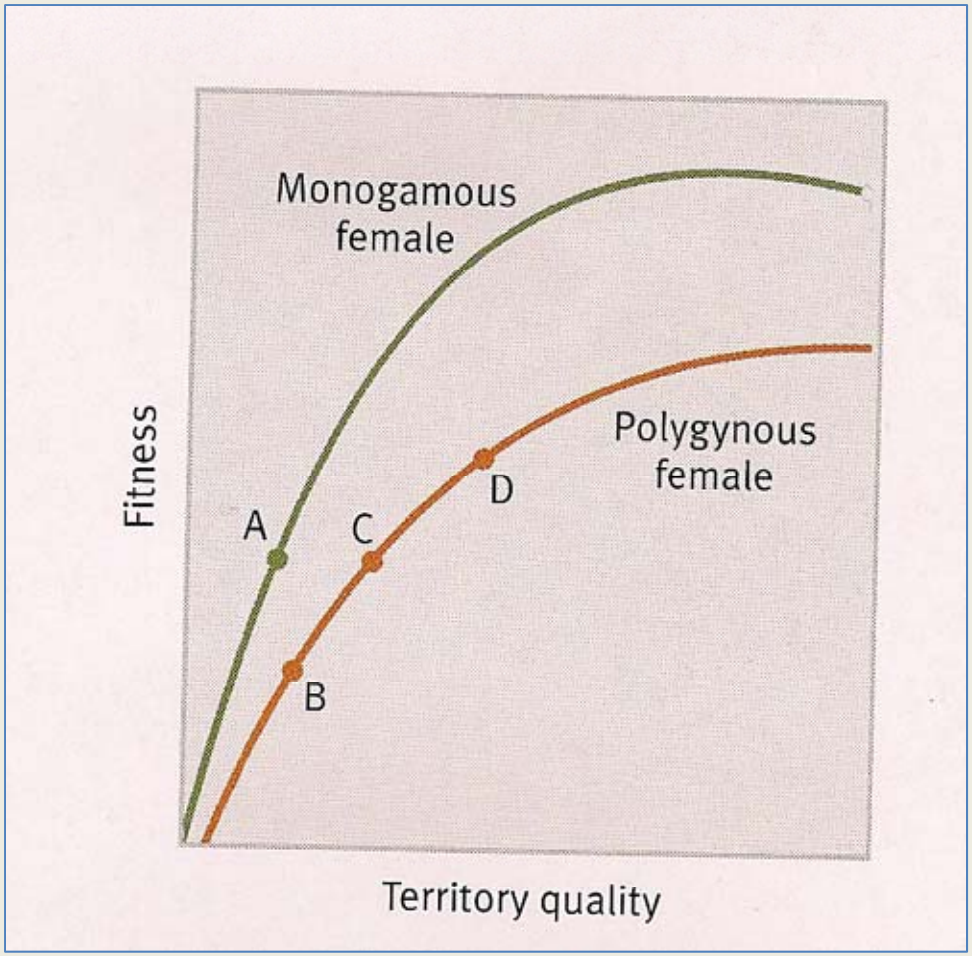
Uneven distribution of resources
(food, shelter…)

Females choose the rich resources, the benefit (for reproductive success) is greater than the cost of parental care all by herself.

# Polygyny threshold model

When the quantity or quality of resources controlled by males varies greatly, females that join already paired males on very rich or very safe territories may have more surviving offspring than if they were to pair off single males on resource-poor territory.

# Polygyny threshold model



# Proximate causes of mating systems

# Proximate causes of mating systems

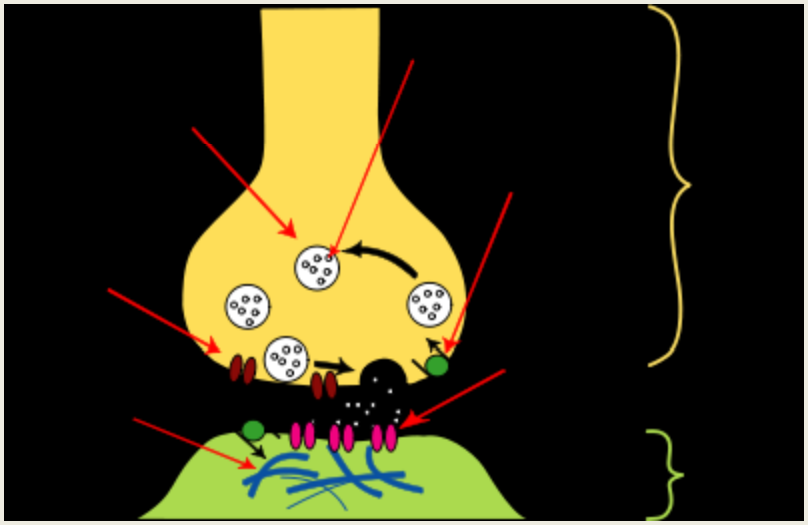
What is the underlying mechanism that control the mating system (genes, hormones)

Monogamy usually required : pair bonding
affection to each other
parental care
mate-guarding

Genes → Hormone and its receptor in the brain
→ pair-bonding, parental behavior

# Dopamine

a neurotransmitter



associated with affiliative / aggressive / addictive behavior

induce dopamine in D1/D2 receptors in the brains (nucleus accumbens)

Dopamine→D1R inhibits pair-bonding
Dopamine→D2R facilitates pair-bonding

# Vasopressin (brain hormone)

One of the most important roles of AVP is to regulate the body's retention of water.

But it also plays a role in social behavior: pair bonding.

Vasopressin receptor, **V-1a receptor**, located in neurons of of the forebrain (ventral pallium).

Vasopressin, when released, binds to V-1a receptor in v. pallium.

Regulate the social behavior-social bonding, social memory.

# Vasopressin (hormone) and pair-bonding

Prairie vole--monogamous

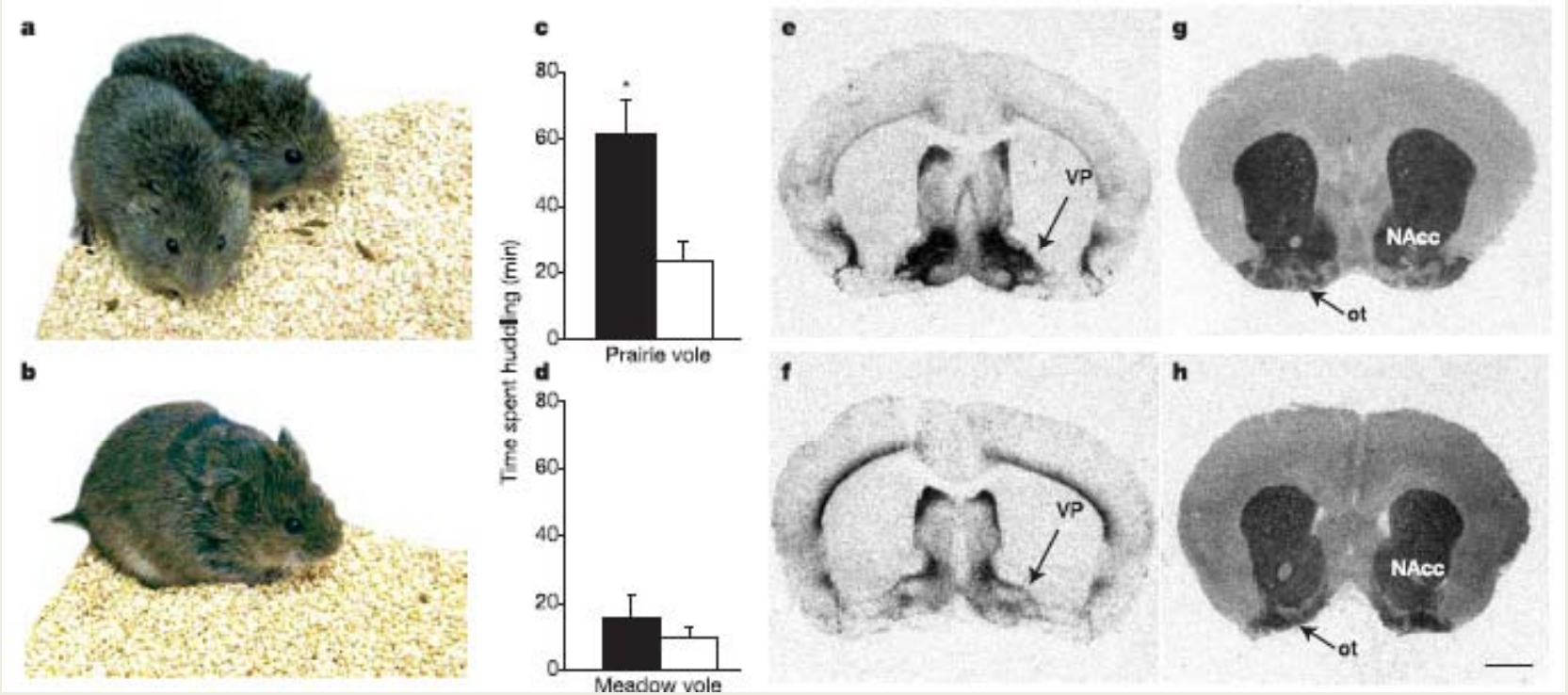
Meadow vole
- solitary, polygamous
(close relatives of prairie vole)

1. Prairie voles have higher **V1aR expression** than meadow voles in the ventral forebrain.

2. Both species have **the same gene V1aR**, same neural pathway for social behavior.

# Vasopressin (hormone) and pair-bonding

1. Prairie voles (monogamous) have higher **<u>V1aR</u>** expression than meadow voles (polygynous) in the ventral forebrain.



# Vasopressin (hormone) and pair-bonding

1. Prairie voles (monogamous) have higher **V1aR expression** than meadow voles (polygynous) in the ventral forebrain.

2. Similar correlation occur in primates and other animals as well.

3. How do we manipulate and test **V1aR expression** is critical for pair-bonding?

   a. Inhibit V1aR expression: infuse V1aR antagonist
      → block pair bond formation

   b. how about increase V1aR expression in v. forebrain

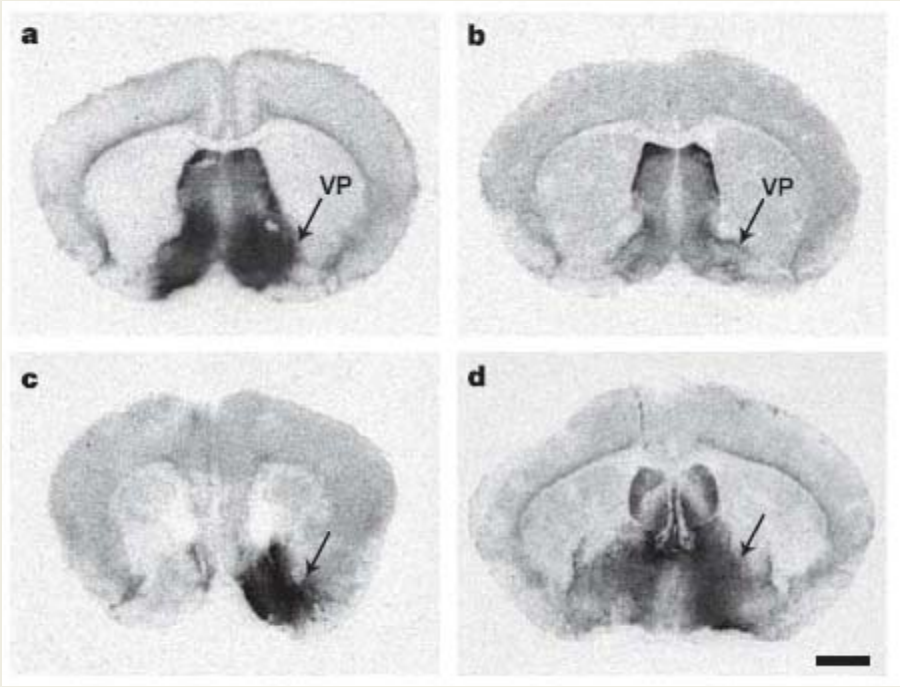
# Vasopressin (hormone) and pair-bonding

Increase V1aR expression in v. forebrain

Use virus to carry the V1aR gene and inject into the v. pallium (VP).

→ over-expression of V1aR gene

→ control groups: inject another gene, inject at nearby locations



# Vasopressin (brain hormone) and pair-bonding

After injection of V1aR in v. forebrain,
polygynous meadow voles spent more time huddling with the partner, or sociable; whereas control voles did not.

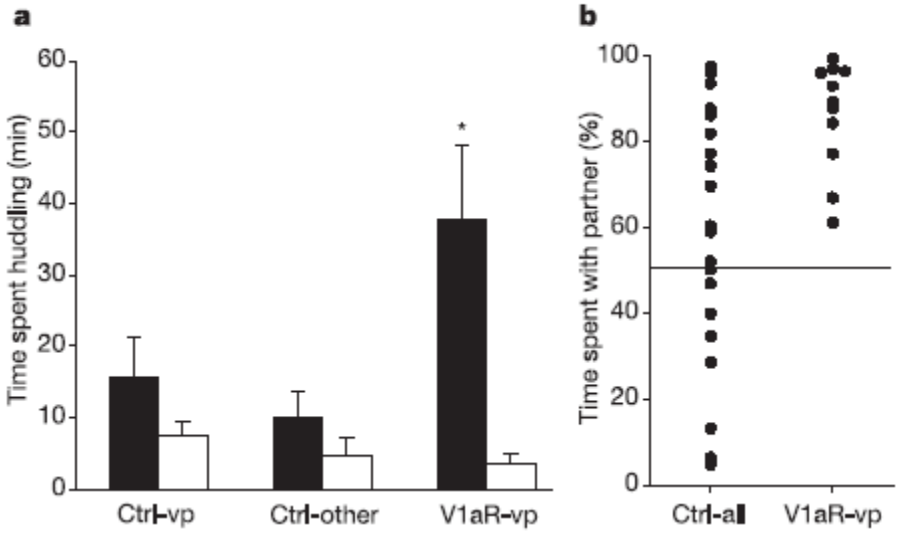



**Figure 3** Partner preference test. **a**, V1aR-vp meadow voles spent significantly more time huddling with the partner (filled column) than the stranger (open column), whereas control animals (Ctrl-vp) and stereotactic misses (Ctrl-other) did not ($P < 0.01$, Student's $t$-test). Error bars, standard error. **b**, A plot of the percentage of time spent with the partner for each subject indicates a shift from randomly distributed preferences in the control groups to 100% of animals preferring the partner in the V1aR-vp group ($P < 0.001$, $\chi^2$ analysis). The $y$ axis was calculated as the time spent huddling with the partner divided by the total time spent huddling with the partner and stranger, multiplied by 100.

# Significance of this paper

A change in the **expression** of a single gene can profoundly alter social behavior. (NO change in the gene itself)

Imply: Evolution of complex social behavior: change gene expression without changing genes or neural pathways

Pair-bonding in human vs. vasopressin and oxytocin (brain hormones)